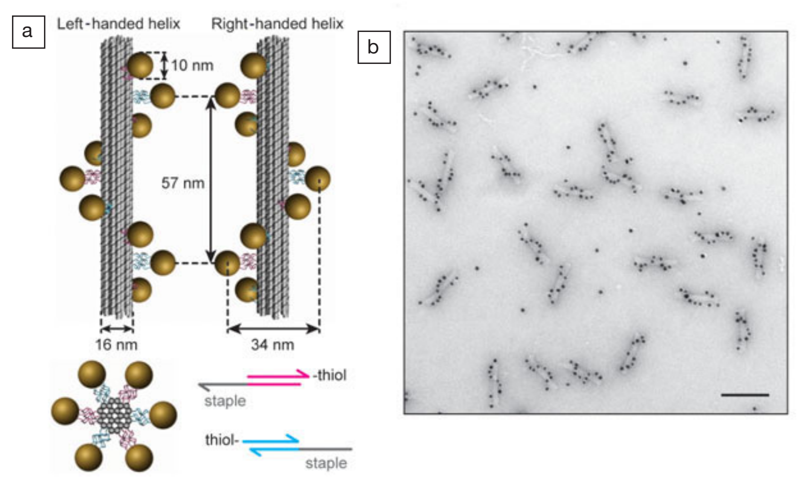
Nano Focus

Gold nanoparticle helices show chiral interaction with visible light

The interaction between light and surface plasmons in metal nanoparticles allows for interesting new optical materials, provided that the nanoparticles can be arranged in precise architectures. Molecular self-assembly provides a promising method for building such plasmonic structures, as shown by A. Kuzyk from the Technical University of Munich, R. Schreiber from Ludwig-Maximilians University (Munich), Z. Fan from Ohio University, and their co-workers, who used DNA origami to assemble helices of gold nanoparticles. Their letter in the March 15 issue of *Nature* (DOI: 10.1038/nature10889; p. 311) describes how these structures interact with polarized light in a similar way to chiral molecules, but at easily tunable wavelengths in the visible spectrum.



(a) Left- and right-handed helices of nine gold nanoparticles that are attached to the surface of a DNA origami structure by thiol-modified DNA linker strands, and (b) a transmission electron microscope image of left-handed gold helices; scale bar 100 nm. Reproduced with permission from *Nature* **483** (2012), DOI: 10.1038/nature10889; p. 311. ©2012 Macmillan Publishers Ltd.

The rational synthesis of a DNA strand which will fold into a target three-dimensional structure, known as DNA origami, was used to provide a scaffold for generating a helical arrangement of nanoparticles. These 16 nm diameter DNA bundles possess nine attachment sites, arranged in one full turn of a 57 nm pitch helix, to which the gold particles (10 nm) were attached by thiol-DNA linkers. Solutions of either all left- or all right-handed helices were then studied using circular dichroism, revealing a difference in absorption between right and left circularly polarized light. As predicted theoretically, coupling of plasmon waves along the helices results in increased absorption of specific polarizations of light, and left- and right-handed helices show a mirror-image peak/dip close to the surface plasmon resonance frequency at 524 nm.

Coating the nanoparticles with a shell of silver (~3 nm thick), which has a shorter wavelength plasmon resonance than gold, unsurprisingly caused a blue shift in the absorption peak. The optical response of the solutions could then be fine-tuned to intermediate absorption frequencies by electroless deposition of a mix of gold and silver, or by mixing helices of different metallic compositions together. The different responses of the left- and right-handed helices could even be visualized macroscopically by passing linearly polarized white light through droplets of the two solutions, which rotate the polarization in opposite directions. The sample could then be oriented so that red light is transmitted by one solution but not the other.

The team also envisage the development of fluids containing oriented helices which could lead to enhanced optical signals, and possibly the production of materials with negative refractive index based on similar structures. This research illustrates in particular how DNA origami can be an effective tool for the engineering of nanoparticle architectures with sufficient precision for optical and plasmonic applications.

Tobias Lockwood

Nano Focus

Figures of merit developed for conductors in metamaterials and plasmonics

Research in metamaterials and plasmonics both involve the study of light in electromagnetic structures. Metamaterials are engineered structures, which are not found in nature, that have an ability to guide light around objects rather than reflecting or refracting it. Plasmonic systems, in turn, exploit surface plasmon polaritons (SPPs), which are electromagnetic waves with wavelengths shorter than the incident light that can propagate at metal–dielectric interfaces. Although incorporation of metamaterials and plasmonics into practical devices promises many exciting applications, their use is limited by significant dissipative losses. These occur because the noble metals used in these photonic structures are poor conductors at high frequencies. Recently, P. Tassin and colleagues at Ames Laboratory—US DOE and the Department of Physics and Astronomy, Iowa State University, and co-researchers at the Institute of Electronic Structure and Lasers, Heraklion, Crete, Greece, have addressed the question of what makes a good conductor for metamaterials and for plasmonic systems. To this end, they have derived two different figures of merit, one for each type of electromagnetic structure.